ES204 -Mechanical Systems
Working Model Lab 02

You will experimentally investigate a swinging rod device (pendulum) and simulate its motion using Working Model.

In this portion of the lab you will compare, in a simulation, the angular velocity of two rods with weights attached that demonstrate rotation about a fixed axis. As you try to predict which rod will rotate faster, you will soon realize that it is not easy to predict and that it is somewhat non-intuitive. You will be able to understand the swinging rod a bit better and you will use the model to help predict the behavior of the swinging rod. At the same time, you will increase your ability to use Working Model.

You will analyze this problem in homework for day 11 (problem 4.38) using principles that you have learned in ES204. You will be required to use this information to predict the behavior of the swinging rod device and to compare your analytical solution to your Working Model solution.

Working Model Instructions

Be sure the units you are using are SI and radians (View/Numbers and Units). It is often convenient to turn on a rulers, grid and axes (View/Workspace)

1. Set the mass unit to grams and the length unit to centimeters. (View/Numbers and Units/more choices)
2. Set view size window width to 230 cm. (View/View Size)
3. Create two rectangles that are 43.2 cm long by 1.5 cm wide (height = 43.2, width = 1.5) and have masses equal to 68.5g.
4. Use a round pin joint and pin the top middle of each rectangle to the background.
5. Modify the equation for the pin to move it down half the radius of the sensor for each rod. Double-click on the pin and modify the formula for the y-location to be:

   body[?].height/2.0-1.25, where ? simply is the object number of the rod.
6. Create a circular object of radius 2.5 cm to act as an adjustable weight. Place a square point element in the center of the circle. Place a square point element in the middle of one rod and, while the point element is highlighted, create a slider control by choosing, Define - New Control - Offset. Delete the x-offset control. Double-click on the word “yoffset” and set the min and max values to 0 and 40.
7. Highlight the two square point elements using shift-click and then click on JOIN.
8. Select the square point element and change the y equation from “Input[?]” to “43.2/2-1.25 – Input[?]”. When the offset is set to zero the disk should be at the pin location of the pendulum.
9. Repeat steps 6, 7 and 8 for the second rotating rod.
10. Set the initial angle of the bars to pi()/2. Double-click on a bar to bring up the properties window and change the angular bar position ϕ from 0 to pi()/2 rads.

11. Create controls for the mass of the adjustable weights. Highlight a weight and choose Define - New Control - Mass. Double click on the word “mass” and set the minimum mass to 1 g and the maximum mass to 1000 g. Repeat for the second mass.

12. Create a meter to measure the angular position and velocity of the left bar. Highlight the left rod Choose Measure-Velocity-Rotational Graph. Click twice on the white arrow in the upper left of the meter and you will have a digital meter rather than a graph. Double click on the graph to call up the properties window and add a plot for the angular velocity of the right bar and the position of both bars. The equations for velocity and position should be something like: Body[?].v.r and Body[?].p.r

13. Create a meter to measure the time (Measure/time)

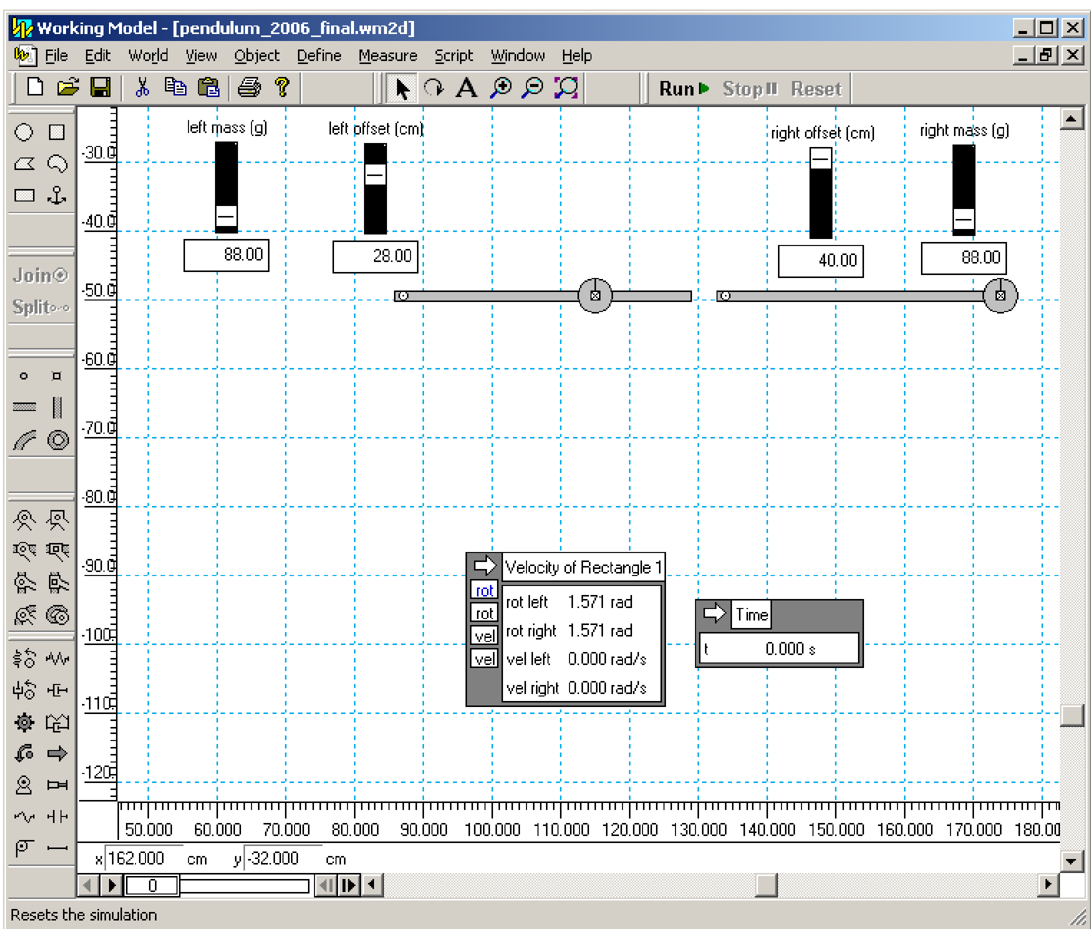
14. Add a pause control for each body. Choose World - Pause Control - New Condition and then type following condition for each body: body[?].p.r < 0

15. Eliminate all contact/collisions by selecting all the masses you have drawn and then go to Object/Do not collide.

16. Use an animation step of 0.001 and an integration error of 0.0001 (World/accuracy)

17. Put an 88 g mass at the end of the bar on the left, an 88 g mass at the end of the bar on the right and run the model.   The model should stop when the rods pass vertical.

A snapshot of what you model may look like is shown below.



Worksheet – ES204 Lab 02 (Due Friday, 12/21/2007 with the homework)

Names ________________________ _________________________ ________________________

1. Place a 0.088 kg mass near the end position (offset = 40 cm) of the left rod and adjust the position of a 0.088 kg mass on the right rod according to the table shown below. Run your simulation and record the angular velocity and time for the right rod to reach the vertical position

Offset (cm)	Time (s)	Angular velocity (rad/s)
4		
9		
14		
19		
24		
29		
34		

Using Excel plot the Time as a function of the offset and the angular velocity as a function of the offset. Attach your plots to this worksheet.

2. Using trial and error determine the location for which the rod will have a maximum angular velocity at the bottom. You may include a table of the points you used on the back of this page.

L_max_working model = _____________________

How does this compare to your solution to HW 4.38? This question is to be answered after you complete HW 4.38. **Attach a copy of your solution to this lab**.

L_max_HW (HW 4.38) = _____________________

3. Explore this problem using your simulation. For example: What happens to the location for maximum angular velocity if you change the mass of the disk?

4. Discussion (continue on the back if necessary).

Attach a snapshot (capture the image and paste it into a Word document, do not use the WM print feature) of your Working Model simulation to this worksheet.